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A new model to assess mathematical power

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Abstract

The main problem of this study was to build up a new model to assess the Mathematical Power (MP). After defining the dimensions of MP, the measurement tools, used for the interpretation of MP, were determined and applied to 62 students from three classes of a primary school, in accordance with the case study methodology, in order to get the qualitative and quantitative data. The data were analyzed by rubrics through the constant comparative analysis methodology. Thus, a picture was obtained showing the MP levels of 8th grade students.

It was determined that, most of the students were not able to reach the expected MP level, especially because of their failures in problem solving, reasoning, communication and making connections. To change this negative picture, some recommendations were presented about teaching materials, structure of standard tests and in-service courses.

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1. INTRODUCTION

It has been known that one of reasons for the failure observed in mathematics course is that a common understanding, attitude and application unity cannot be accomplished in evaluating target and learning-teaching experiences which are the elements of teaching process (Çoban, 2002). If mathematics teaching is likened to a chain, content, learning environment, the role of the teacher and the methods of the student for evaluating his mathematical understandings are the rings of this chain (Sparkes, 1999). Therefore, even the curricula designed with the best principles are not able to lead to any changes in classroom application if the evaluation methods remain the same.

Mathematical Power (MP), the topic of this study, was defined after reviewing the related literature (Schoenfeld, 1992; Sparkes, 1999; Greenwood 1993; Parker, 1995; Baroody and Coslick, 1998; Brizendine, 1999; Yackel, 2000; Ernest, 2002; Alkan and Bukova, 2003; Curtis, 2004) as “the efficacy of the individual for using his conceptual and operational knowledge within the framework of determined content in solving the experienced problem situation utilizing his reasoning, communication and connection skills together” (Mandacı Şahin, 2007). Thus, MP can be stated as follows.

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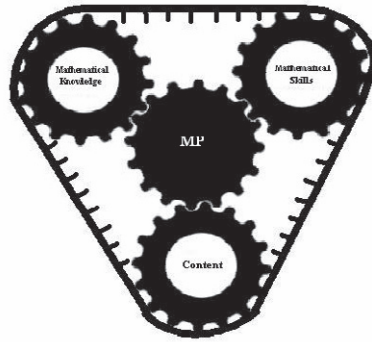


Figure 1. The Mathematical Representation of MP Dimensions

As it can be understood in Figure 1, it is expected that the product obtained when a student utilizing his mathematical knowledge with his mathematical skills together within the framework of determined content is the indicator of MP.

In the light of this attitude, the general target of basic educational programs related to the mathematics course in the whole world is to develop Mathematical Power (MP). However, this target is ignored in the steps of evaluation which is one of the most important elements of a program and standard tests for ordering and choosing are applied to the students. Therefore, the target of the program and the target of the evaluation contradict; and because of this contradiction, determining the level of reaching program targets becomes impossible. Thus, it is a must to determine whether the program reach its targets by means of a well-structured evaluation approach. It is inevitable to feel the need for a multi-dimensional system in the evaluation of MP which is a combination of complex and multi-dimensional behaviors.

The purpose of this study is to indicate the applicability of an assessment model which handles MP, a multi-dimensional behavior, with its all dimensions.

2. METHOD

In studies on the development of MP, each student was taken into account as a special case and the process was evaluated in this way (Greenwood, 1993; Parker, 1995; Baroody and Coslick, 1998). Therefore, in this study in which it was aimed at evaluating the MP, it was found to be appropriate to use case study method which enabled to collect both quantitative and qualitative data through various tools.

2.1. Data Collection Tools

When the related studies were reviewed, an agreement on the necessity of utilizing various methods and tools which could exhibit the students' individual characteristics and were related to evaluation of both process and product in order to make decisions on the development of MP which was a multi-dimensional behavior was seen (Maers, Stinka and Henderson, 2002; NCTM, 1995; NCTM, 2000; McIntosh, 1997; Barker, 2003).

Evaluating MP model is fundamentally based on the portfolio assessment method. The tools in student's portfolio can be classified under two groups. These are the data collection tools used in evaluating cognitive and affective characteristics. Although, in some tools (observation and interview) data related to both characteristics can be collected, student identification card (SIC), sentence completion test (SCT), mathematics attitude scale (MAS), mathematical resume (MR) take place in this portfolio for the affective characteristics and observation form (OF), multiple choice test (MCT), open-ended test (OET) and clinical interview (CI) for the cognitive characteristics.

2.2. Data Analysis

Qualitative and quantitative data collected by means of data collection tools were analyzed in three steps by means of constant comparative analysis method. If this data analysis method based on a kind of elimination method is summarized briefly; in the 1st elimination the 30%, 30% and 40% of the scores of the students from MCT, OET and CI respectively were taken and a numerical value was obtained for MP. In this elimination, the students whose scores were under 30% were eliminated; because, these students remained under the lowest level of MP and they need an extreme support.

In the 2nd elimination, the students' performances in each MP dimension were examined with OF and the accordance with the numerical values was examined creating a general profile. For example, the score of the student from the communication skill in the 1st elimination was compared with the communication skill score in OF and the reasons of this result was explained with the field scores. In addition to this, the affective characteristics of the student were associated with the results of MP dimensions and a profile about the relationship of students' MP levels, attitudes and individual characteristics.

In the 3rd elimination which was the last step, the relationship between the levels was presented taking the comparisons of students at the same levels and at different levels into account. For example, at which points students at the lowest level and at the highest levels differentiate and the relationship of other MP dimensions or individual characteristics with students' exhibiting individual characteristics of lower or higher levels instead their own levels were mentioned. Thus, multi-dimensional MP evaluation was completed for each student in the sampling.

At the end of the analysis of the data, the results were associated and MP levels of the students were determined. When the related literature (Greenwood, 1993; AMUSE, 1995; Baroody and Coslick, 1998) was reviewed, it was decided that MP could be taken as levels not with numbers. What level means here was students' efficacy to reach the determined targets. As MP was a kind of efficacy, it was decided that MP levels could be named as "low, efficient, and high". According to this, all data obtained through all data collection tools had to be taken into account together in order to determine at which level a student was. Thus, the students who expressed themselves in different ways were given the equal opportunities. As a result, the application of this model in which problem solving, decision making, communication, making connections and conceptual and operational knowledge dimensions were evaluated separately and in relation with each other and which was called as the assessment model of MP (AMMP) could be seen in Figure 2.

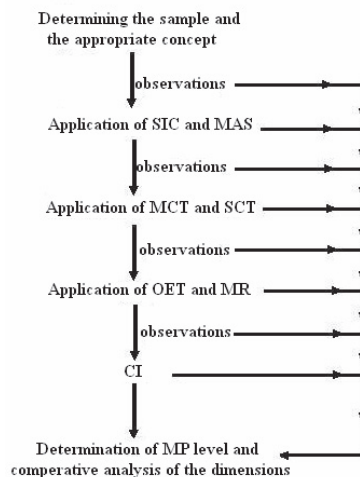


Figure 2. The application schema of AMMP

One of the most important elements of the assessment was the determination of the content. The content that formed the conceptual framework of the study was composed of the general objectives of Primary School Mathematics Program (MEB, 2002) for the secondary section.

2.3. Participants

The developed AMMP was applied to 62 students enrolled at the 8th grades of a primary school in Trabzon province for one semester (28 course-hours).

3. FINDINGS

3.1. The Findings Obtained in the First Elimination

In this step, students' scores of MCT and OET and CI scores which were examined with evaluation rubrics were summed up and a quantitative MP score was found. According to this, of the 18 students, 1 was at the high level, 5 were at the efficient level and 7 were at the low level of MP. The rest 5 of them were determined to be at the very low level of MP as they could not exhibit even the behaviors expected from the students at the low level.

3.2. The Findings Obtained in the Second Elimination

In this step, the findings of students' MCT, OET and CI results were examined with the findings of observations; thus, what kind of behaviors students exhibited in each MP dimension were examined and their MP levels were determined.

3.3. The Findings Obtained in the Third Elimination

In the third step in which the performances students exhibited in each MP dimension and their MP levels were compared, the findings related to the relationship between the MP levels and academic achievement, attitude and gender were examined.

In the light of the data obtained, it was found that MP dimensions had to be taken as a whole without any separation and giving each of them an equal place would give more detailed results. In addition to this, the performances exhibited in MP dimensions were compared among themselves and in terms of which MP dimensions students developed in the MP levels they took were also examined.

4. CONCLUSION AND RECOMMENDATIONS

The following conclusion was drawn in the light of the findings obtained from AMMP, the content and application of which was explained in detail in the methods section:

1. When the evaluation rubrics in which pre-determined criteria take place are given place in the analysis of data obtained from the measurement tools in AMMP, it would be possible to observe the students' developments as not only products but also process is evaluated.
2. It is possible to claim that MP level is developed when students, who connect their conceptual and operational knowledge properly, make evaluations and present the problem encountered after solving.
3. In the determination of MP levels of students, MP dimensions are closely related to each other; moreover, MP dimensions are related to each other at a high level.
4. When the dimensions of MP are given place equally, more detailed and realistic findings can be obtained in MP evaluations.

5. Of 18 students in the sampling, 1 (5%) of them was at the high level, 5 (28%) of them were at the efficient level, 7 (39%) of them were at the low level and 5 (28%) of them were at the very low level.
6. The MP levels of the students are not the indicator of the fact that their performances in all dimensions are at this level.
7. Contrary to the standard tests from which only statistical data is obtained, AMMP enables to take all characteristics of the students, to determine the strengths and weaknesses of the students and the program, and thus, to make a holistic evaluation about the effectiveness of the program.
8. AMMP can be used to reveal mathematics knowledge and understanding at all levels of primary education.
9. Teachers can use the required ones of the AMMP tools based on the structure of the topics and they can reorganize the scoring according to this. From this perspective, the model has a flexible structure. Moreover, in-service trainings for teachers can be organized about the application of this kind of evaluation.

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